iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 9 Issue: VI Month of publication: June 2021

DOI: https://doi.org/10.22214/ijraset.2021.35202

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue VI Jun 2021- Available at www.ijraset.com

Design of New Convex Lens Shaped Y Splitter for better Optical Communication

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Abstract: This Paper describes, a photonic crystal waveguide based a Y-splitter. The outcomes of this Y-splitter are fixed by mechanisms of plane wave augmentation and Finite Difference Time Domain (FDTD). A lattice structure of hexagon shape is chosen as a basis for the formation of waveguide structure for the designing of Y-splitter. Subsequently, the calculation of power in transverse magnetic mode in equivalent the power calculated of the dual output ports of the proposed device.; the proposed device design of the splitter dispenses moderately greater transmission efficiency. This is affirmed by the simulation results obtained from the work done. The splitting ratio for both the halves was almost at 46%, and the aggregate radiation loss was confirmed to be almost 8 % for each output port. Therefore, the suggested Y-splitter is estimated as a better and more efficient as compare to basic splitter and ASS modified splitter.
Index Terms: Waveguide, Transverse magnetic mode (TM), Splitter, PBG, Photonic Crystal

I. PROLOGUE

PHOTONIC crystal structures are considered as promising building blocks for use in integrated photonic circuit i.e., also called PICS. Some structures are based on planar photonic crystals (PhCs). In such waveguides, the optical field is confined, horizontally, by a photonic band gap (PBG) provided by the PhC and, vertically, by total internal reflection due to refractive index differences. Various PhC components, such as waveguides, bends, Y splitters, and directional couplers, have already been realized [1-8]. These basic building blocks can be combined to realize complete circuits with various optical functions within a very small area. In the most commonly employed configuration, a photonic crystal waveguide is formed by introducing a single line defect [2] into a two-dimensional 2D PhC slab. In such PhCs waveguides, light is confined by a combination of in-plane photonic Band Gap (PBG) confinement and vertical index guiding. Photonic crystals (PhCs) have been also used for miscellaneous applications, as a highly successful and unique platform for manipulating light in microscopic dimensions and design their dispersions for particular needs [10]. PhCs have the potential in Realizing optical processors to meet the need for higher cpu speeds. So the important elements related to Photonics Integrated Circuit are light division i.e. power splitter, light filter, optical multiplexers et.al. In the following work, a streamlined and methodical power convex lens is formed (Y-splitter) based on the photonic crystal waveguide. The suggested device is formed by changing the composition of the Y-junction, where a pair of convex lenses is desegregated in every corner of the suggested design. As a result, this recasting requires transmission of greater amount of power from the input side to output side in comparison with the original structural design. The conventional design of splitter and the suggested splitter are studied by using the polarization method of transverse magnetic mode., by using the PWE [10] method for the calculation of the band gap while the output spectral characteristics and transmission of power is evaluated by FDTD method [11]. Experimental results after the various simulations shows that there is an improvement in the performance factor of the suggested device better than the performance of the original device design, the transmitted power almost 92 % total with every channel evenly furl out 46 % of total input power, even though the original layout deliver 44 % of input power to every channel.

II. BASIC CONCEPT OF SPLITTER STEMMED FROM PHOTONIC CRYSTALS

As we know that basic of photonic crystals are capable in guiding, controlling, manipulating which leads to discover many new devices. In this paper the analysis and study of photonic crystal waveguide-based structure -i.e., splitter is trying to design at the base ratio of splitting wave guide of 50- 50percent into 46 percent to make it 21*21 size array layout which is of hexagonal lattice type. As the name suggest splitter divides the input transmitted power into two or more than two ways its principle of working is just like that of multiplexer and that transmitted or input light emitted from a particular source of light energy likewise LED, LASER etc that we have used. We can analyse these powers of Y-splitters with the help of two methods that is Finite Difference and time domain method and

Plane Wave Expansion method (PWE). As a matter of fact, these techniques customarily modify electromagnetic waves from stated Maxwell's equations in order to delineate their propagation in various mediums. The power output of splitter device is calculated in the electromagnetic domain and spectral transmission ratio is stated as follows:

$$\boldsymbol{P} = -\mathbf{1/2}\,\boldsymbol{Re}\left[\int \boldsymbol{Ei}\,\boldsymbol{Hi}^*\right]$$

Where, Ei: incident electric field

$\boldsymbol{H}i^*$: conjugate of magnetic field(incident)

III. DRAFTING OF THE SUGGESTED SPLITTER

Figure 1(a) represents conventional layout design of the "Y" splitter in a lattice of hexagonal design consisting 21×21 array [10]. This layout is taken in a two-dimensional PhC (XZ) plane. Air holes are present in the silicon slab base having a refractive index of n_{Si} = 3.4 and thickness of all aspects (WC) = 220 nm. Hole radius =160nm (r=0.4xa) where a=400 nm. The "Y"-juncture is composed of a linear waveguide on input side and two different branches of waveguide on output side are held together.

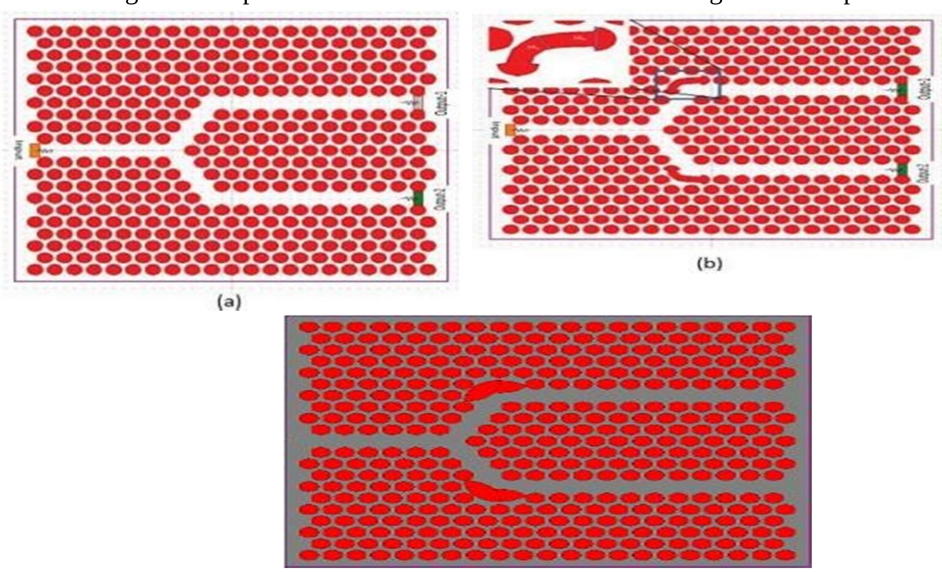

Figure1: Schematic of the power "Y" splitters based on PhC (a) Basic (b) conventional arc shape structure (ASS) (c) proposed convex shaped structure (CSA)

Ideally the power transmitted from input terminal must be dividing equally into two output parts (see figure1(a)) but in CS there is an arc shaped structure (ASS) our assignment is based on the recasting of the Convectional structure, i.e. by drawing Convex lens shape slot by removing the two holes at the edge of Y-part of output terminal in the splitter which is based on photonic crystal waveguide. The width of lens is 0.88 µm and its front and back radius are 0.6 µm and -0.6 µm respectively [10]. We have used two lenses in this proposed structure is designed as the two convex lenses are made to join one another in a V-shaped like structure [13].

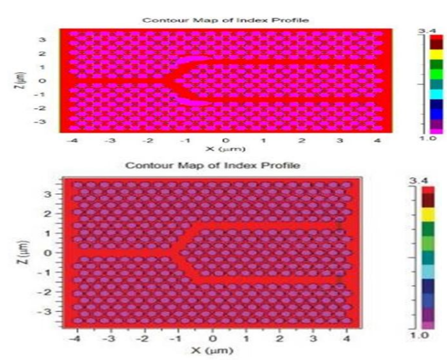

Figure2: Refractive index outline of the Power splitter (a) original (b) suggested Structure.

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IV. OUTCOMES AND COMPARISION

A. *Cross Sectional design of 'Y'-Split Device*

Figure 3 depicts the refractive index variation of the duo splitting devices to determine the variation between these two device design splitters w.r.t various optical properties. From the figure, it can be concluded that the channel and the background are shown by a red colour which determines the value = 3.4 while all circles are shown by a purplish hue with a refractive index equal to 1 while, as shown in figure 3a) and 3b). In figure 3b), adding ASS at the second curvature of the channels, being represented by a purplish colour (air).

B. *PBG Sketch*

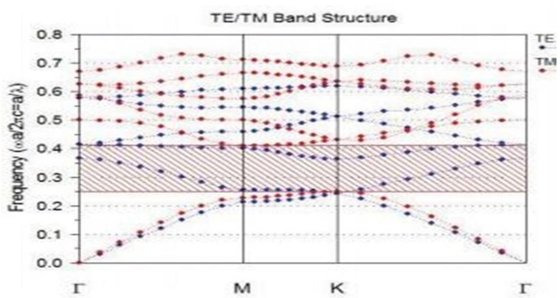

Figure 3: Photonic Band Gap in TE and TM modes is shown in the band gap figure.

We have calculated Band diagram [4] by using Plane Wave Expansion method (PWE) which refers to a computational technique to solve Maxwell's equations for the basic structure of 21*21 hexagonal size holes in a rectangular slab.
The area where no EM wave propagation of light wave occur in any mode but here in TM mode w. r. to wavelength is the Band Gap formation here the Band Gap is in the range of

$$0.25<a/\lambda<0.41$$

$$975\ .60\ \text{nm}<\lambda<1660.66\text{nm}$$

$$0.000625<1/\lambda<0.01$$

Where λ is the wavelength of light and a is lattice constant, which shows both of the 1300 nm and 1550 nm wavelengths which are included in the PBG, hence these are apt for usage in optical communication and other telecommunication services.

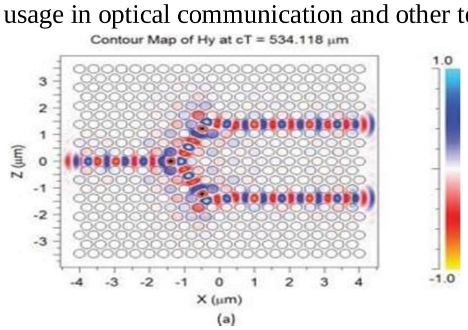

Figure4: TM light wave propagation inside the cs splitter

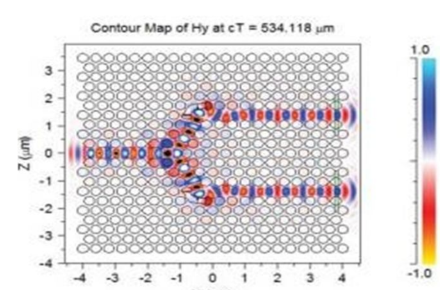

Figure5: TM light wave propagation inside the proposed splitter

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C. Analysis of Power Spectrum of Splitters

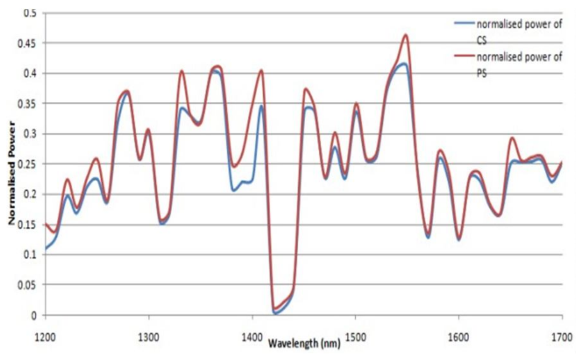

Figure5: Normalized power variation in the output as a function of wavelength

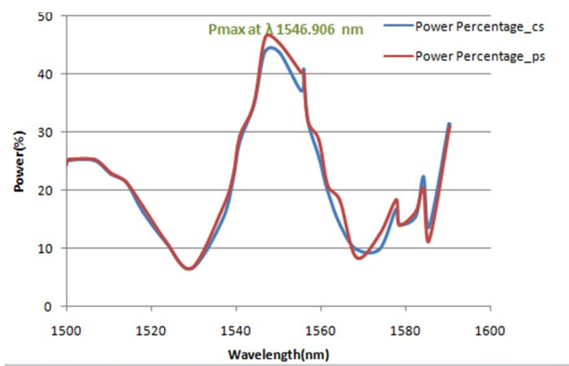

Figure 6: Radiation loss w.r.t wavelength

Here we use FDTD method which is an acronym for finite difference time domain method and it is also a numerical method which is optimized and powerful technique for determining parameters on nanometer scale also for its modelling. In this method we illustrate the variation of power of suggested and original splitter design in figure 6 and figure 7 respectively. This power variation is with respect to wavelength in nm scale at two ports.

Basically, our aim is to design splitter to divide the power at two ports equally i.e., 50% but we cannot achieve our power due to radiation losses which can be minimized but cannot reach up to zero. Practically it must be there it can be minimized as far as possible [13].

We can clearly state from the graph both the powers i.e., PS and CS are almost underlying to one another which are shown by red and blue colours in graphs. We find normalized power through above mentioned numerical technique and its maximum value that is achieved is 45.8% approx. 46% which is according to our proposed structure while in previous manner it is 44 percent with corresponding wave length of 1550nm which is a rise of 2 percent in normalized power [4]. So, we can say that it has been further improvise to reduce radiation loss effects up to 8% which is 12 % in conventional structure.

V. CONCLUSION

A new enhanced structural design of the PhC "Y"-splitter has been formed in this paper. The layout of the new optical "Y"- splitter is composed of a lattice of hexagonal shape of air holes 21 × 21 figured on Silicon chip and there is an imperfection of two convex lenses shaped is placed by removing the two holes in the Y-part i.e., output part in order to divide the power into two equal parts and also to reduce radiation losses. We have calculated normalized power and radiation losses of the SS and it is classified and analysed by the expansion of plane wave and Finite difference time domain method respectively. Simulation outputs hereby, affirms the suggested splitter provides comparatively greater transmission efficiency. The splitting ratio for both (50-50) was at 45.8% which is approximately 46% and the gross radiation loss has been reduced to 8%. Thus, our aim to increase transmission efficiency and reduce radiation losses for optimum utilization in optical communication [14] and also in photonics integrated circuits has been almost achieved in a successful manner.

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